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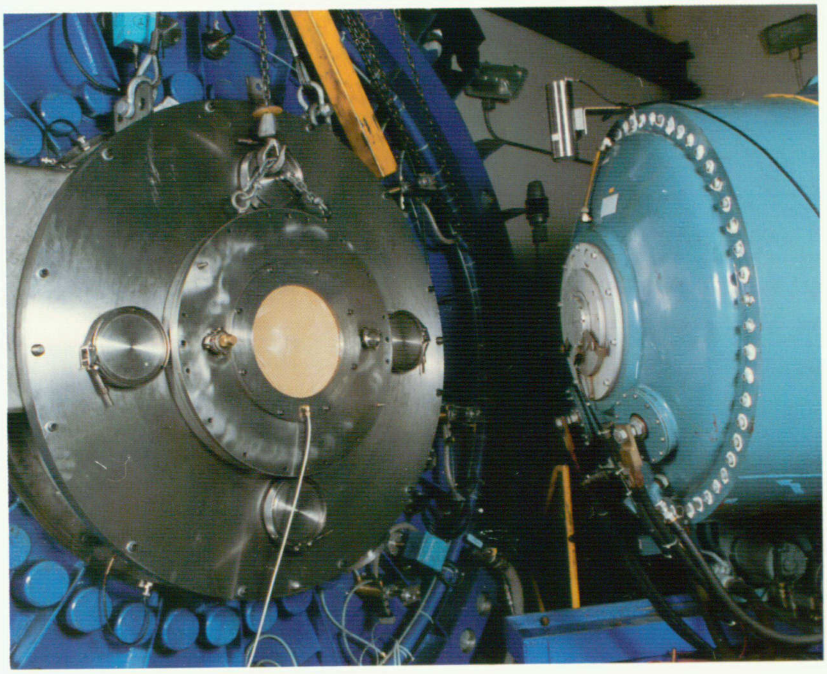
RADIATION FACILITIES

AT

NSWC



Defense Nuclear Agency

NAVAL SURFACE WARFARE CENTER

Dahlgren, Virginia 22448-5000 • Silver Spring, Maryland 20903-5000

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The Electronic Hardening Building (132) houses Casino II, Phoenix, and TAGS.
The Navy's Vulnerability and Hardening Building (130) houses the Febetrons and Colbalt 60 Source.

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Introduction

General

The requirement for nuclear hardened equipment and systems creates a new and unique challenge for all developers of new systems. At the Naval Surface Warfare Center (NSWC), a solid base of technology exists for hardening strategic and tactical systems.

This brochure describes the machines and facilities available at NSWC for conducting initial nuclear radiation (INR) and Transient Radiation Effects on Electronics (TREE) experiments and tests.

The facilities at NSWC are primarily dedicated to the study of the effects of prompt gamma and x-rays on electronic components, circuits, and equipment. Both tactical and strategic electronics may be tested at NSWC. The facilities feature a complete range of flash x-ray and pulsed electron beam machines including the Defense Nuclear Agency's (DNA) Casino and Phoenix machines. A 2,000-Curie Co60 source is also available for total ionizing dose tests on components and small circuits.

The majority of the facilities described in this brochure are located in a two-building nuclear effects complex located at the White Oak, Maryland, laboratory which includes the Navy's Nuclear Vulnerability and Hardening Building and the DNA Electronics Hardening Building. The facilities may be used by any agency of the U.S. Government and by commercial companies engaged in nuclear effects work for the Department of Defense (DoD) (see "Using Facilities," Page 13).

Army-Navy Radiation Effects Test Consortium

NSWC and Harry Diamond Laboratories (HDL) have entered into an agreement to form a joint Army-Navy Radiation Effects Test Consortium. The following facilities are part of the consortium:

- The DNA Aurora Facility, HDL
- The DNA Casino and Phoenix Facilities, NSWC
- The Army HIFX Facility, HDL
- The DNA/Navy TAGS Facility, NSWC
- The Navy Radioactive Materials Handling Lab, NSWC
- The two Febetron 705s, a Cobalt-60 Source and an NSWC Febetron 706, NSWC

The consortium was formed to establish a Center of Excellence for radiation effects testing and to better serve the users of the facilities. NSWC and HDL will cooperate to schedule users planning to use facilities at both sites. The joint resources of the two organizations will be used to better meet the users' needs and to advance the state-of-the-art of radiation effects testing. Questions concerning taking advantage of the services offered by the consortium can be answered by calling either HDL on 301-394-2290 or NSWC on 301-394-1209.

Simulators

Flash x-ray machine is the name commonly applied to that family of radiation generators that produce an intense, very short pulse of photons in the gamma or x-ray portion of the electromagnetic spectrum. The radiative output of these machines is produced by stopping a pulsed beam of high energy electrons in a high Z-material, typically tantalum or tungsten, and is called bremsstrahlung radiation. The electron beam is normally generated by discharging a capacitor bank, such as a Marx generator, into a pulse forming network, usually a large coax line, and then switching this energy into a cold cathode field emission diode. The resulting electron pulse is normally in the 3 to 70-nanosecond regime and may contain anywhere from a few joules to several hundred kilojoules of energy depending on the size of the machine. The discharge of this much energy in nanoseconds results in power generation ranging from billions to trillions of watts. The conversion of the electron pulse into a gamma or x-ray pulse is very inefficient with somewhat less than 2 percent of the electron beam energy appearing as electromagnetic radiation in the gamma and x-ray regime.

Simulation Fidelity

The spectral distribution of the photons produced by the flash x-ray machines is a function of the voltage used to generate and accelerate the electron beam. The spectral distribution of the photons produced by the bremsstrahlung process will have an intensity inversely proportional to the electron energy. As the photons travel through the target and the debris-catcher materials, this distribution will be modified due to absorption, fluorescense, and attenuation in the materials. The peak of the x-ray or gamma ray population exiting the debris-catcher will occur at an energy level around 1/5th of the peak electron beam energy. For example, if the electron beam is a 1 MeV monotonic beam, the photon peak will occur around 200 keV.

In the x-ray regime, the effects on electronics are usually very sensitive to the energy (wavelength)* of the x-rays. It is important, therefore, that x-ray effects work be conducted with a radiation spectrum that represents the actual environment as close as possible. The spectral fidelity required for gamma ray effects testing is far less demanding since the effects are generally insensitive to photon energy over much of the gamma ray spectrum.

The radiation pulse width is also an integral part of simulation fidelity since effects generally fall into two categories, dose rate limited and dose limited. It is important, therefore, to have a broad range of radiation pulse width options available for effects experiments so that rate sensitive phenomenon can be observed.

*The wavelength of a photon is related to its energy by the equation: $\lambda(\mathrm{cm}) = 1.24 \times 10^{-10}/E\ (\mathrm{MeV})$

Facility Overview

The family of machines at NSWC have been organized to provide the experimenter with the best prompt gamma and x-ray simulation fidelity available. They offer the experimenter a wide range of output levels, spectra, and pulse widths for INR and TREE testing at all levels of the electronics hierarchy. Table 1 lists the machines available at NSWC and describes the radiation effects tasks to which they are best suited.

Table 1. NSWC Radiation Simulators

MODEL	RADIATION	POWER (10^9 Watts)	WIDTH (10^{-9} SEC)	PRIMARY USE
Febetron 706	X-ray	3	3-4	Prompt X and gamma ray tests on small parts and tactical radiation detectors.
Febetron 705	Gamma	20	20-25	Prompt gamma ray tests on strategic and tactical parts, circuits, and boards.
Febetron 705X	Gamma	30	20-25	Prompt gamma ray tests on strategic and tactical parts, circuits, and boards.
TAGS	Gamma	180	25-30	Prompt gamma ray tests on tactical equipment and large circuit boards.
Casino	X-ray	500	50-70	Prompt X-ray tests on stratetgic piece parts and components.
Phoenix	X-ray	4,000	40-60	Prompt X-ray tests on subassemblies, circuits, and parts for strategic systems.
Cobalt 60	Gamma			Total ionizing testing of components and small circuits.

Description

Phoenix

The DNA Phoenix machine is the largest machine at NSWC. Phoenix is a low-voltage flash x-ray machine with a nominal pulse width of 40 ns to 60 ns. The electron beam energy can be varied from 1 MeV to 1.5 MeV. At the higher voltage, Phoenix generates about 200 kJ of beam energy and converts this energy into an area weighted mean dose of 30 krads(Si), over a 1000 cm^2 area, at a dose rate of 5×10^{11} rads(Si)/sec. The normal rate for Phoenix is two to three shots per eight-hour day for a typical experiment. The Phoenix is supported by a computerized system which provides a full range of machine and experiment diagnostics (see Instrumentation, Page 18). A drawing of the Phoenix machine is shown in Figure 1 and a list of its output characteristics is shown in Table 2.

The Phoenix machine is ideally suited to the testing of strategic missile electronic assemblies and some of the larger components used in these weapons. The Phoenix source is about 8.5 feet above the exposure room floor. A large seismic pier is located in the floor on the center line of the Phoenix machine. A large test fixture can be mounted to the seismic pier to raise inertial devices and gyros up to the source for testing. For normal electronics testing, an elevated platform is used to bring experiments and personnel up to the source.

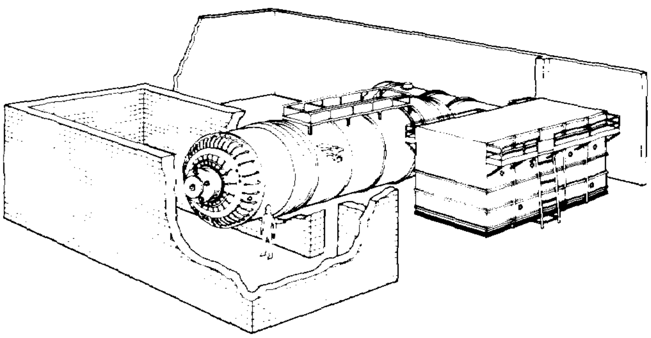


Figure 1. Phoenix Simulator

Table 2. Phoenix Output and Operating Characteristics

BREMSSTRAHLUNG CHARACTERISTICS

AREA (cm^2) ($D_{min}/D_{max} > 0.5$)		1,000	10,000
AREA-WEIGHTED MEAN DOSE	$B_{1.0}$	8	0.8
krad (Si)	$B_{1.5}$	30	3
AREA-WEIGHTED MEAN DOSE RATE	$B_{1.5}$	1×10^{11}	1×10^{10}
rad (Si)/s	$B_{1.5}$	5×10^{11}	5×10^{10}
FLUENCE	$B_{1.0}$	0.2	0.02
cal/cm^2	$B_{1.5}$	1.0	0.1
MAXIMUM DOSE*	$B_{1.0}$	11	1
krad (Si)	$B_{1.5}$	14	1.4
MAXIMUM DOSE RATE*	$B_{1.0}$	2×10^{11}	2×10^{10}
rad (Si)/s	$B_{1.5}$	7×10^{11}	7×10^{10}

*OVER SIGNIFICANTLY SMALLER AREA THAN SHOWN. ISO-DOSE CURVES AVAILABLE UPON REQUEST FROM FACILITY MANAGER.

—X-RAY PULSE FWHM: 40-60 ns
—RISE TIME: 25 ns

SOURCE GEOMETRY

- SOURCE ℄ IS 8.5 FT ABOVE LAB FLOOR

OPERATIONAL INFORMATION

- PROJECTED 2 TO 3 SHOTS PER DAY

DOSIMETRY/DIAGNOSTICS (FOR PHOENIX AND CASINO)

- WIDE VARIETY OF DIAGNOSTICS AVAILABLE. TAILORED TO USER NEEDS. THESE INCLUDE CaF_2 TLD'S, PHOTO DETECTORS, PINHOLE CAMERAS, AND SPHERE ARRAY SPECTROMETERS
- EXPERIENCED STAFF AND OTHER FACILITY SUPPORT AVAILABLE

INSTRUMENTATION
(FOR PHOENIX AND CASINO)

- COMPUTER BASED DATA ACQUISITION SYSTEM: AST386C; EIGHT TEKTRONIX 7912 DIGITIZERS AND SEVERAL 7000 SERIES OSCILLOSCOPES; 8 FAST LECROY DIGITIZERS AND 32 SLOW LECROY CHANNELS

- DEDICATED SCREEN ROOM: 25 ft × 14 ft

- SEISMIC PIER

- LARGE VOLUME (19 ft × 36 ft) SHIELDED TEST CELL

Casino II

Casino is designed to simulate the effects of x-rays on electronic components. In the x-ray mode, Casino produces a dose of approximately 100 krads(Si) over 10 cm² and delivers a dose rate greater than 1.5 × 10^{12} rads(Si)/sec at the face. Casino's effective pulse duration runs between 50 to 70 ns in the x-ray mode with a total energy of approximately 40 kJ at 0.8 MeV. When Casino is operated in the e⁻beam mode (i.e., without a bremsstrahlung converter), the machine can deliver 60 kJ of electron energy per pulse. Additional output information and operating characteristics are presented in Table 3 along with a sketch of the Casino machine (Figure 2).

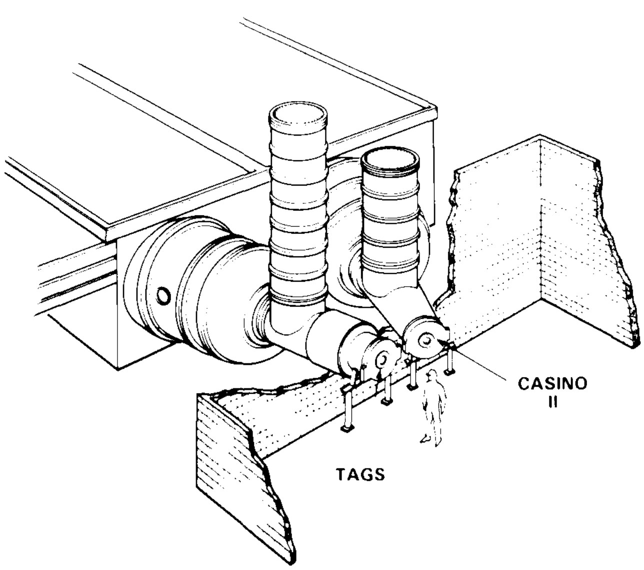


Figure 2. Casino Simulator

Table 3. Casino Output and Operating Characteristics

BREMSSTRAHLUNG CHARACTERISTICS

Area (cm²) (D_{min}/D_{max} > 0.5)		10	100	1,000
AREA-WEIGHTED MEAN DOSE krad (Si)	$B_{0.8}$	100	10	1.4
AREA-WEIGHTED MEAN DOSE RATE krad (Si)/s	$B_{0.8}$	1.4 × 10^{12}	1.4 × 10^{11}	2 × 10^{10}
MAXIMUM DOSE* krad (Si)	$B_{0.8}$	180	15	2
MAXIMUM DOSE RATE* rad (Si)/s	$B_{0.8}$	2.6 × 10^{12}	2.2 × 10^{11}	2.9 × 10^{10}

*OVER SIGNIFICANTLY SMALLER AREA THAN SHOWN. ISO-DOSE CURVES AVAILABLE UPON REQUEST FROM FACILITY MANAGER.

—X-RAY PULSE FULL WIDTH HALF MAXIMUM (FWHM) 50-70 ns
—RISE TIME: 40 ns

ELECTRON BEAM MODE

TARGET AREA cm²	25	MAXIMUM BEAM CURRENT kA	550
DOSE (CARBON) cal/gm (C)	870	MAXIMUM CURRENT DENSITY A/cm²	21,000
MAXIMUM DOSE RATE cal/gm (C)/s	1.2 × 10^{10}	ENERGY FLUENCE cal/cm²	330
UNIFORMITY ($\delta_{min}/\delta_{max}$) cal/gm/cal/gm	0.9	TOTAL BEAM ENERGY kJ	40
		MEAN ELECTRON ENERGY MeV	0.7

– E-BEAM FWHM: 70 sn
MAGNETIC GUIDE FIELD: 20 kG

SOURCE GEOMETRY

- SOURCE ℄ IS 66 INCHES ABOVE LAB FLOOR

OPERATIONAL INFORMATION

- NORMAL OPERATION: 3 TO 5 SHOTS PER DAY

NWE simulators with Casino's x-ray spectrum and intensity are rare. Casino offers the experimenter an intense x-ray exposure and good spectral fidelity, with a tolerable pulse width. The machine is particularly well suited to the study and testing of spectrally sensitive phenomenon such as thermally generated effects and system generated electromagnetic pulse (SGEMP) and is especially well suited to the testing of strategic components used in reentry vehicles.

The Casino exposure area is unrestricted and can accommodate a large variety of test fixtures. The machine can deliver four shots in an eight-hour day and is supported by an excellent user and machine diagnostics system.

TAGS

TAGS (TActical Gamma ray Simulator) is a joint DNA/Navy flash x-ray machine which is specifically designed to test full size tactical electronic equipment in the prompt gamma environment.

TAGS generates a 4.5 MeV bremsstrahlung spectrum and produces approximately 1×10^{10} rads(Si)/sec over an area about the size of a standard piece of rack-mounted equipment. The TAGS pulse width is nominally 25 to 30 nanoseconds. The TAGS exposure area, spectrum, pulse width, and dose rate are ideally suited to the characterization of tactical prototypes and existing equipment and for the verification testing of hardened equipment. The complete electronic packages of most tactical missiles can be tested in TAGS *in situ*. TAGS is the result of an extensive modification to one of the original Casino pulselines. It is located adjacent to Casino and shares its Marx generator. This unique arrangement allows a user to expose his experiment to the gamma rays from TAGS or to the x-rays from Casino without moving the experiment. Plans are currently underway which will allow Casino and TAGS to be fired simultaneously, if need be, so that the combined effects of the two ionizing radiation spectra can be assessed.

TAGS and Casino fire into an exposure cell adjacent to the Phoenix test cell. The layout of the three machines is shown on the main floor plan of the Casino Facility, Figure 3.

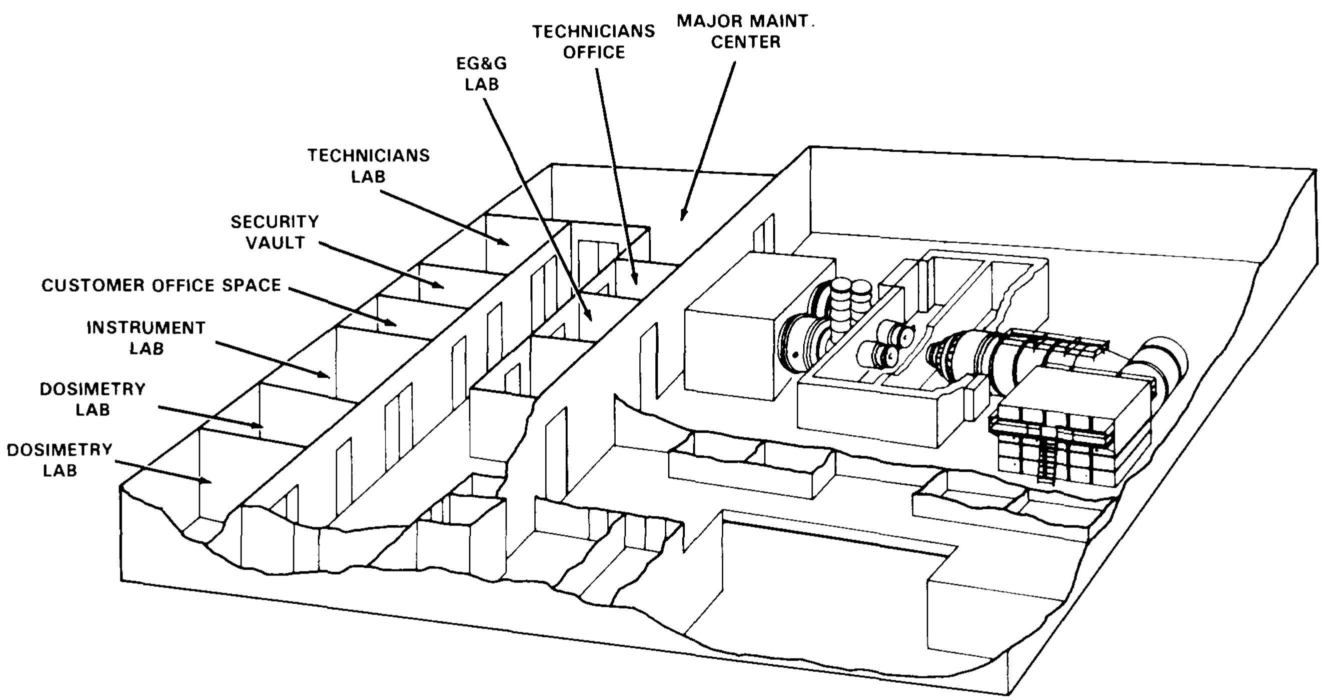


Figure 3. The Phoenix, Casino II, and TAGS Simulator Trio at NSWC

Febetron 706

The Febetron 706 is the smallest of the flash x-ray machines available at NSWC. Despite its small size, the Febetron 706 is an extremely useful machine for nuclear weapons effects testing because of its extremely short (3-4 ns) pulse width. The 706 delivers approximately 100 rads(Si) in 4 ns at the target face over an area about the size of a dime. This is equivalent to a gamma dose rate on the order of 2.5×10^{10} rads(Si)/sec. The rate falls to about 2×10^{7} rads(Si)/sec, over a substantially larger exposure area, about a foot from the target face. These rates coupled with the 4 ns pulse width make the 706 ideally suited to the testing of radiation detectors and triggers,* especially those used to initiate circumvention and radiation protection and recovery circuits. The machine is also very useful for determining the dose limiting value for logic upset or switching of small high-speed components in the short pulse regime. The 600 keV electron beam of the 706 has also been used for tracking down certain types of component failures caused by x-rays. A photograph of the 706 instrumentation is shown in Figure 4, and a list of its performance characteristics is shown in Table 4.

*To protect equipment from tactical size nuclear weapons, detectors must respond to relatively low dose rates with pulse widths equal to or less than 5 nanoseconds.

Figure 4. Febetron 706 Control Console

Table 4. System Specifications for the Febtron 706

TOTAL OUTPUT BEAM ENERGY	12 joules
OUTPUT CURRENT PULSE DURATION (FWHM)	4 nsec
MAXIMUM BEAM ENERGY DENSITY (ON AXIS, AT TUBE FACE)	8 joules.cm^2
SURFACE DOSE IN ALUMINUM, 1/4″ AWAY FROM THE FACE	4 Mrads
LINEAR EXTRAPOLATED RANGE IN A1. EQUIVALENT ELECTRON ENERGY	100 mg/cm^2 600 KeV

X-RAY OUTPUT;

PULSE DURATION (FWHM)	>4 nsec,
X-RAY DOSE/PULSE MAX. (JUST OUTSIDE X-RAY TARGET) 12″ FROM TUBE FACE X-RAY RATE OUTSIDE TARGET	100 rads(Si) 80 mrads(Si) 2.5×10^{10} rads(Si)/sec

FEBETRON 706

Febetron 705

The 705 is an extremely useful simulator because of its ability to do a large variety of NWE testing. The 2.3 MeV bremsstrahlung output of the 705 is well suited to gamma ray testing of components and circuits. At the target face the radiation intensity per pulse is around 4000 rads(Si). The full-width, half-maximum of the 705's radiation pulse is nominally 2.5 ns and the gamma rate is approximately 1.5×10^{11} rads(Si)/sec. This rate is available over an area slightly smaller than a quarter which is sufficient for most component response testing. At 30 cm from the target face, the exposure rate drops to 5 × 10^8 rads(Si)/sec over an area of about 400 square cm. Here the rate is well suited to response testing of tactical electronic circuits. The pulse width of the 705 strikes a happy medium for most prompt gamma ray effects tests.

The 705 is simple and inexpensive to use and its radiation output is very reproducible. The Marx generator of the 705 can be charged from about 12 kV to 35 kV resulting in electron pulses with energies from about 600 keV to 2.3 MeV, respectively. The 35 kV charging level is the most frequently used operating mode. The 705 can be fired at a rate of about one shot every five minutes. Occasionally this rate has to be interrupted to allow the machine to cool. The 705 can also be used in the electron beam mode. A charging voltage 35 kV can produce an electron beam with a pulse width of 50 ns and a total energy of about 400 joules.

In both modes of operation, the 705 uses a dc magnetic field to focus the electron beam. This field can be several hundred gauss at the x-ray target holder with the strongest field lying along the axis. The experimenter should be aware of the presence of this field and its possible effects on experimental apparatus and circuit response. Except for experiments involving magnetically sensitive parts, the presence of the field is seldom a problem. A photograph of the Febetron 705 is shown in Figure 5, and a description of its normal output characteristics is presented in Table 5.

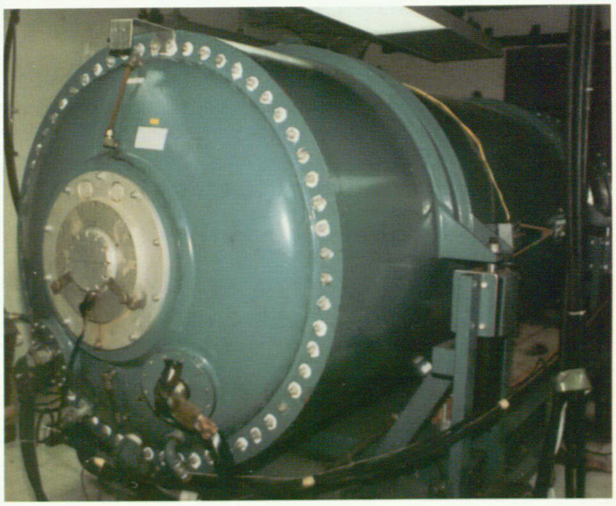


Figure 5. Febetron 705

Table 5. Typical Operating Characteristics for the Febetron 705 and 705X Flash X-Ray Machines

FEBETRON	705	705X
MAXIMUM CHARGING VOLTAGE	35 kV	40 kV
TUBE VOLTAGE (MAX. ELECTRON ENERGY)	2.3 MeV	2.8 MeV
TOTAL BEAM ENERGY PER PULSE	400 J	590 J
PEAK ELECTRON BEAM CURRENT	5000 A	6000 A
PULSE WIDTH (FWHM) ELECTRON MODE	20-50 ns	20-50 ns
X-RAY MODE	20-25 ns	20-25 ns
GAMMA RATE AT TUBE FACE (ANODE)	1.5 × 10^{11} rads (Si)/sec	2.5 × 10^{11} rads Si/(sec)
30 CM FROM TUBE FACE	5 × 10^8 rads (Si)/sec	1 × 10^9 rads Si/(sec)
GAMMA RAY INTENSITY PER PULSE AT TARGET	4000 rads (Si)	6200 rads (Si)
30 cm FROM TARGET	15-20 rads (Si)	25 rads (Si)

Febetron 705X

The 705X is a specially modified version of the 705 which is capable of generating a peak electron beam energy of about 2.8 MeV and a correspondingly higher bremsstrahlung output and higher average photon energy. The x-ray intensity of the 705X at the target face is about 50 percent higher than that of the 705. In all other respects the 705X is identical to the 705. It is equipped with a water-cooled focusing magnet which allows for beam extraction at the higher operating voltage and permits a higher shot rate than is possible with the air-cooled 705.

The real utility of the 705X is its ability to expose larger pieces of electronic equipment to prompt gamma rates and spectrum similar to those found in tactical environments.

Cobalt 60

A 2000-curie cobalt 60 source is also available at NSWC. The source is a self-contained unit with two small exposure chambers (10″ × 10″ square and 14″ deep) for irradiating components and circuits with 1.25 MeV gamma rays. Corkscrew holes give access to the exposure chambers from the outside and allow power supply and data cables to be connected between the test specimens and instrumentation. The source is ideal for small active experiments and components testing. A photograph of the cobalt 60 source is shown in Figure 6, and a dimensional sketch of the cobalt 60 source is shown in Figure 7.

Figure 6. CO60 Source

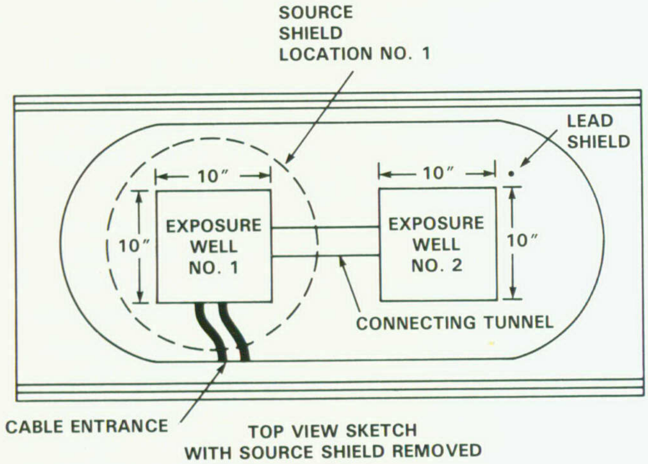


Figure 7. Sketch of CO60 Source

NOTES Bounded Wave EMP Simulator

The Naval Ordnance Transient Electromagnetic Simulator (NOTES) is a bounded wave simulator (BWS) which produces an electromagnetic pulse (EMP). This facility produces a vertically polarized E-field peaking at 100 kV/m with a rise time of less than 10 ns and a fall time of about 1 μs. A 90 percent uniform field will be available in a working volume 8 meters by 2 meters by 6 meters high. This facility is scheduled to be in operation the end of fiscal year 1990 at Dahlgren, Virginia. A sketch of the NOTES BWS is shown in Figure 8.

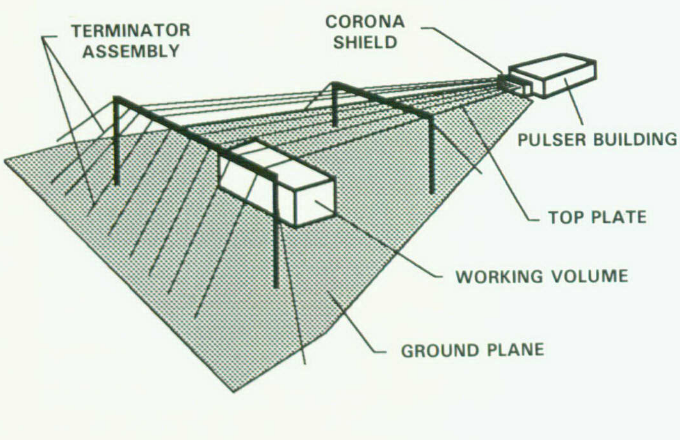


Figure 8. NOTES BWS

Electronically Driven Explosive Shock Simulator (EDESS)

EDESS is a vertical axis shock generator capable of producing MIL-S-901 type shocks in a wide range of payload weights. EDESS uses stored electrical energy to develop simulated underwater explosive (UNDEX) shock by means of the magnetic repulsive force developed between pairs of spirally wound electromagnetic coils.

A wide range of mounting options are available or can be fabricated in-house to facilitate testing equipments to shock levels greater than 100 g's and 10 ft/sec for payloads up to 15 tons. EDESS generates highly repeatable, infinitely variable shocks over the full range of the simulator.

A wide range of data acquisition and recording equipment is available in-house. Specialized shock instrumentation and analysis support is available in conjunction with the NSWC shock test group. A photograph of the EDESS machine is shown in Figure 9.

Figure 9. EDESS

EMPRESS II — One-Fourth-Scale Electromagnetic Pulse Generator

By mid-1990, the EMPRESS II Proof-of-Principle Pulser will be installed and operational at NSWC. This pulser is a one-quarter scale working model of the EMPRESS II free-field EMP pulser used by the Navy to test surface combatants to the full threat EMP level. The proof-of-principle pulser will be used as a direct-injection rather than a free-field test facility for simulation of high altitude electromagnetic pulse. The facility will be suitable for testing power lines, communication lines, and related equipment. The pulser will be adaptable for radiated EMP tests and insulation breakdown tests. A sketch of the proof-of-principle pulser is shown in Figure 10. The pulser performance parameters, facility diagnostic data, and test object data follow:

PULSER PERFORMANCE DATA:

- Output Voltage: 100 kV to 2 MV
- Pulser Effective Impedance: 60 to 600 ohms
- Rise Time (0 to peak): 10 to 20 ns
- Decay Time (peak to 1/e of peak): 500 ns to 1/5 μs
- Polarity: Reversible
- Charging Time: ≤ 60 seconds

FACILITY DIAGNOSTIC DATA:

- Pulser Charge Voltage
- Monocone Output Voltage (including rise time, decay time)
- Marx Output Voltage

TEST OBJECT DATA:

- Pulse Voltage and Current
- Test Item Internal Voltages and Currents
- Open-Shutter Photography During Test

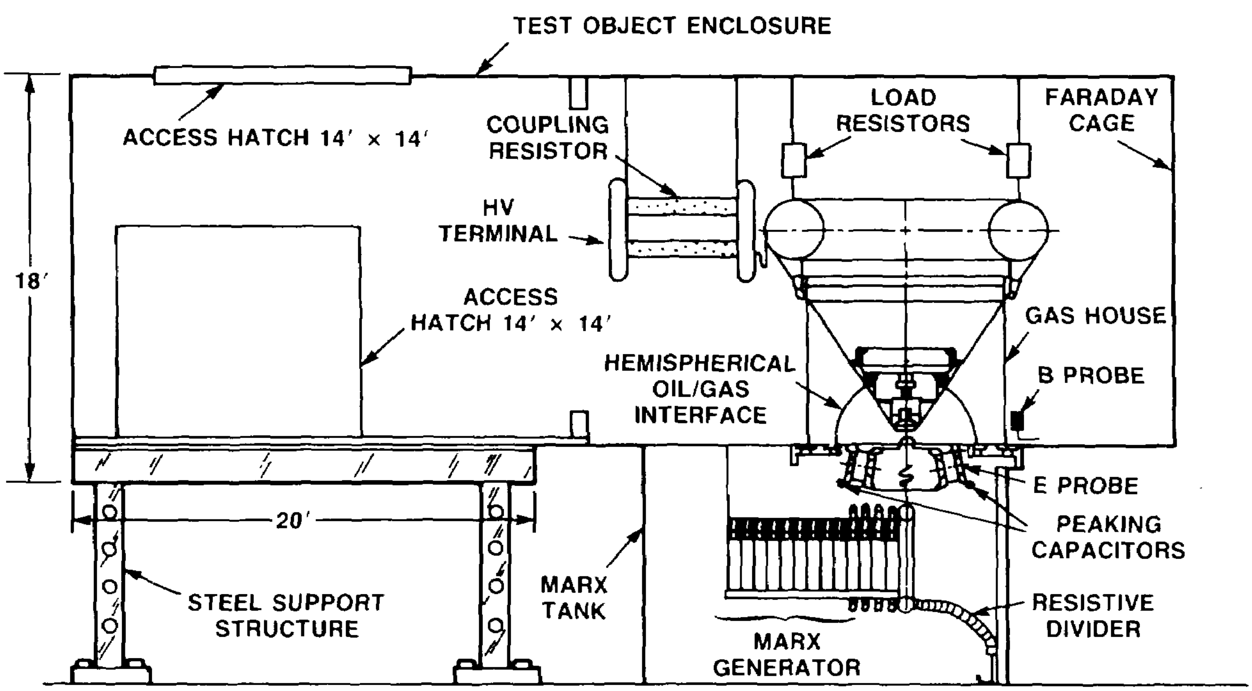


Figure 10. Proof-of-Principle Pulser

Using the Facilities

Eligibility

The NSWC radiation facilities may be used by any agency of the U.S. Government or any commercial organization working on radiation effects under contract to DoD.

Prospective users may make inquiries about the facilities or their use by calling or writing the Electronics Hardening Branch at NSWC, White Oak. The telephone number is:

(202) 394-1878

The address is:

Naval Surface Warfare Center
White Oak Laboratory
Attn: Code H23, Ops Assistant
10901 New Hampshire Avenue
Silver Spring, MD 20903-5000

Scheduling

All scheduling and arrangements are coordinated by the Operations Assistant (OA). The OA can advise you on the administrative procedures, schedule openings, and costs. If you have technical questions, the OA will put you in contact with a technical staff member who can answer them.

Prospective users who have never visited the facilities or who have not visited them for some time are encouraged to do so before planning an experiment in great detail. The arrangements for these visits are also coordinated by the OA.

The NSWC radiation facilities have been organized to be user friendly. The staff and management have done everything possible to reduce the administrative burden on the user to an absolute minimum and to make the users' experiment at NSWC a productive experience. However, if we are to be successful, the user must follow the established procedures. Getting an early start is the first step.

The NSWC facilities, especially the Casino, Phoenix, and TAGS machines, are normally heavily subscribed. It is important, therefore, that a user schedule his experiment as far in advance as possible. For the major machines three months is considered a minimum lead time; six months is a better arrangement since there are several things which must occur before an experiment can actually take place. A lead time of two to three months is recommended for smaller machines.

Once a user is scheduled, certain administrative and planning obligations are required so that scheduling can continue to move along smoothly. A list of these, laid out for a twenty-four week lead time, is given in Figure 11.

WEEKS

STAGES	0	2	4	6	8	10	12	14	16	18	20	22	24
1. Initial Contact	●												
2. Preliminary Visit		●											
3. General Program Plan				●									
4. Liability Agreement						●							
5. Transfer of Funds							●						
6. Security Clearances on File							●						
7. Detailed Technical Test Plan							●						
8. Technical Planning Meeting at Site								●		●			
9. Revised and Final Test Plan													
10. Ship Material to Site												●	
11. On-Site Setup													●
12. Experiment Starts													●

Figure 11. Scheduling List

Items 3, 4, 5, 6, and 7 or 9 as appropriate from Figure 11, should be on file before an experiment begins. In special cases, some of these requirements may be combined or waived to facilitate conduct of the test. Funds for scheduled tests must be received at least two months before the scheduled test or the reserved time may be forfeited unless other arrangements have been made. The required documents are outlined in the following paragraphs.

General Program Plan (GPP)

The GPP is the initial formal contact document between the prospective user and NSWC. The principal purpose of the GPP is to provide an overview of the proposed test so that the facility staff at NSWC can obtain some initial insight into the objectives and the scope of the test and tentatively place it in the schedule. The GPP should present the following information:

1. Title of experiment
2. Agency name or contractor and number
3. Objective
4. Desired Simulator
5. Type of test (i.e., x-ray, e-beam, etc.)
6. Proposed Schedule
7. Funding Arrangements (Corporate check, MIPR, etc.)
8. Program (What program is the test related to?)
9. Participants (List key contact and phone number.)

Liability Agreement

Certain users of the NSWC Radiation Facilities may be required to file a liability agreement before using the facilities. As a general rule, agencies of the U.S. Government are exempt from this requirement as are users who are working on experiments funded by MIPR. Certain contractors who pay by corporate check may also be exempt providing they can show that the legal agreements have been satisfied in the Government's contract under which they are working.

Transfer of Funds

Funds may be transferred to the Radiation Facility in several ways. Corporate checks may be used or the sponsoring agency or organization may MIPR (Military Interdepartmental Purchase Request) the money to NSWC. Checks should be mailed to the Facility address and MIPRs should be addressed to the attention of the Operations Assistant. When estimating the amount of funds to send, keep in mind that the daily rate only covers the actual test and setup; if other services are contemplated, such as machining, optional dosimetry, electronics fabrication, shipping, etc., extra funds for these services should be added to the funding transferred. Cost estimates and rates are available from the Operations Assistant. All funds should be in-house before testing begins. The mailing address is:

Naval Surface Warfare Center
White Oak Laboratory
Attn: Operations Assistant
Code H23, Bldg. 132
Silver Spring, MD 20903-5000

Security Clearances

Clearances must be on file for every person who will visit the facilities or participate in the experiment. Clearance requests should be sent to:

Naval Surface Warfare Center
White Oak Laboratory
Attn: Receptionist/Visitor Control, Code X11
10901 New Hampshire Avenue
Silver Spring, MD 20903-5000

The point of contact should be the Operations Assistant, Code H23.

Detailed Technical Test Plan (DTTP)

The DTTP is the technical working document for the experiment. The DTTP should list all of the details pertinent to the setup and conduct of the test. It should be developed in sufficient detail to let the NSWC staff set up the machine and provide all of the required supporting services in a proper and timely manner. Incomplete DTTPs are probably responsible for more delays, misunderstandings, and poor experiments than any other single factor. The user should file his DTTP at least two weeks prior to his pre-test meeting at the site. This will give the staff time to review the DTTP and have a list of questions for the user at the time of the meeting. At the meeting, the DTTP will be discussed in detail and changed or modified as appropriate. The user will incorporate the changes and file the Revised and Final Test Plan prior to reporting for the actual test. The OA will furnish each user with a standard DTTP format to help with his preparation of the DTTP. The DTTP will include the following items:

1. Title

2. Agency Name (or contractor's name)

3. Specific Objectives of the Test

4. Technical Approach (The user should address the following items in the Technical Approach)

   a. Description of the Test Specimen—Describe as completely as possible the details of the test specimen, including its dimensions, desired placement in front of the machine, any supporting hardware, and any special handling precautions. Are there any explosives in the test specimen or liquids or gases which might explode when exposed to heat or radiation?

   b. Support Equipment—Describe the equipment that you will bring to the test and where it will be located during the test, i.e., in the test cell or the rf screen room, etc., what is its function, its size, and its weight?

   c. Conduct—Describe how the test will be conducted. Show the test setups for each series of shots. If you intend to fire the machine, indicate it here. Will the test be active or passive? Will there be any special timing required? Describe it.

5. Facility Support

   a. Radiation Diagnostics—Describe the radiation diagnostics support which will be required, the type and number of measurements desired per shot, and the dose or dose rate levels necessary to meet your test requirements. The degree of dose and dose rate uniformity over the test area is also important and should be included.

   b. Instrumentation—Describe, in detail, the instrumentation support that will be required. List all of the cables, equipment, and data channels that you wish the facility to furnish and any special power requirements other than 120 VAC, 60 Hz.

   c. Mechanical Fixtures—Using shop sketches, describe any special fixtures or jigs that you want the Facility to furnish.

   d. Photography—List the photographic services you will require.

   e. Handling—Describe any special handling equipment that you will need, such as fork lifts, cranes, hoists, etc.

   f. Transportation and Storage—Describe any special storage requirements (classified, refrigerated, etc.) and transportation support that you will need.

The information in the DTTP is designed to help us provide you with the best test support possible. It has evolved to its present form after many years of successful simulation testing. Feel free to add any pertinent information to the DTTP that you think is important to the conduct of your test.

Radiation Diagnostics

A diverse system of user-oriented radiation diagnostics is available for characterizing and measuring the photon radiation from the NSWC nuclear weapons effect simulators. The typical diagnostics of interest to users are the dose and dose rate measurements. The standard dose diagnostic is the thermoluminescent dosimeter (TLD) which is used in conjunction with a scintillator-photodiode photodetector to determine the peak dose rate. The dose and dose rate values are calibrated in terms of rads(CaF_2) and rads (CaF_2)/sec, respectively. These values can be converted to rads(Si) and rads(Si)/sec upon request. Available options include: spectrometers, pinhole cameras, and additional photodetectors. The following paragraphs highlight the radiation diagnostics used at the Facility.

Dose Diagnostics

The primary radiation dose diagnostic used at NSWC is the calcium fluoride manganese-activated (CaF_2:Mn) TLD. TLDs are used with all the radiation sources described in this brochure. Two types of CaF_2:Mn TLDs are in use: (1) 100 percent CaF_2:Mn (hot pressed chips and rods) and (2) 5 percent CaF_2:Mn in a teflon-disc matrix. The "chip" has a useful dose range from 0.01 to 100,000 rads(CaF_2). The "disc" TLD has a useful range from about 50 to 300,000 rads(CaF_2). Bulb type CaF_2:Mn TLDs are also available, but are seldom used for simulator diagnostics. All TLDs are normally packaged in aluminum, equilibrium shield capsules when they are exposed to radiation. The typical capsule measures about 0.5 inch diameter. For the 0.6 MeV to 1.5 MeV machines, the capsules are about 0.125-inch thick, while for the higher energy machines (>2 MeV) the capsules are about 3.5 times thicker. Smaller capsules are available and can be used if the situation allows. A photograph of the TLDs and the shields is shown in Figure 12.

When an exposed TLD is heated, it gives off an amount of light proportional to the radiation exposure it received. The light is measured by a very sensitive photomultiplier and electronically equated to the radiation dose absorbed by the TLD; hence the name thermoluminescent dosimeter. We use the Harshaw Model 2000 TLD analyzers for the majority of our TLD readouts. An Apple II computer interfaced with the Harshaw, is used for data processing and output formatting. The TLD data are presented to the user in page format. TLDs are currently processed at a rate of one per 90 seconds after a 15-minute set-up time per readout session (see Figure 13). Readout of TLDs is usually not started until 60 minutes after an exposure in order to minimize errors from prompt thermoluminescent fading effects. A Victoreen TLD analyzer is available for the Febetron and Cobalt 60 users. If you are familiar with this type of equipment, we can arrange for you to use this analyzer on your own.

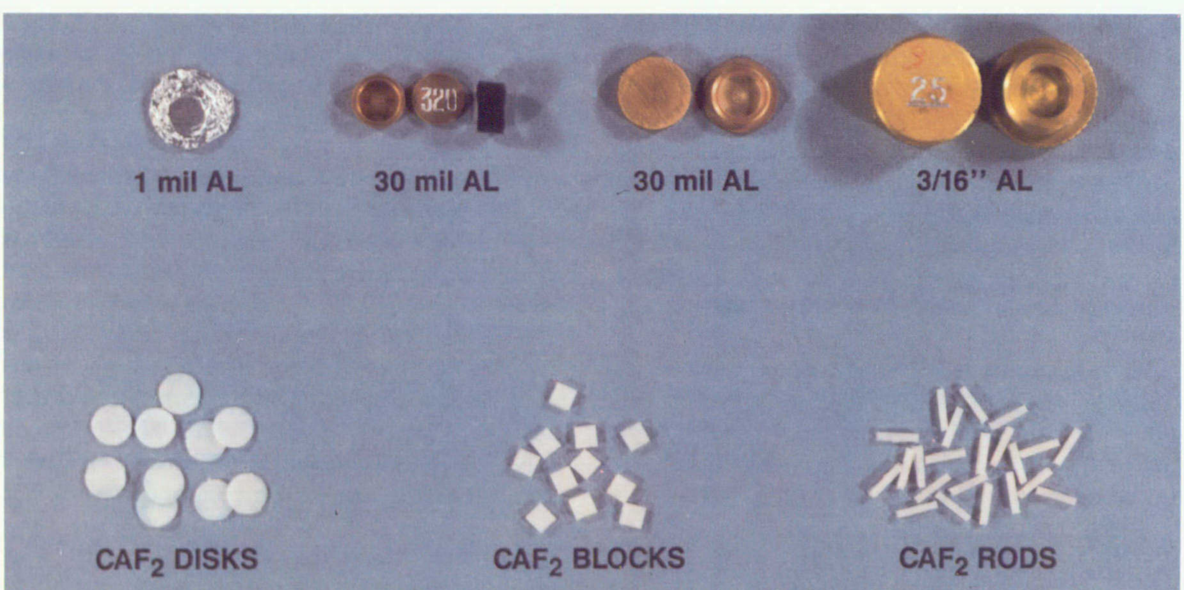


Figure 12. Radiation Diagnostics

Dose Rate Diagnostics

A scintillator-photodiode photodetector and TLDs can be used to determine the peak dose rate at various locations of interest to the user. Usually one photodetector is placed at a standard location where the pulse shape is representative of the pulse at the user's experiment. TLDs are placed around the user experiment at the actual locations where dose rate measurements are wanted. The dose measured by each TLD is used to calibrate the photodetector response in terms of rads/sec from which the peak dose rate at each location can be obtained. This calibration is done by relating the integral of the photodetector pulse to the dose measured by the TLD. Dividing the measured dose by the peak dose rate gives a value we call the effective pulse duration. This value is different from the measured Full Width Half Maximum (FWHM) of the pulse and should not be confused with it.

Figure 13. Dosimetry Lab

Optional Diagnostics

The following diagnostics are available at NSWC but are not part of the standard dosimetry package. The use of these diagnostics must be specifically requested in the DTTP and the details worked out with the Facility Dosimetrist. There is an additional charge for most of these services.

Spectrometry

The primary diagnostic used to characterize the Casino and Phoenix spectra is an absorption sphere array spectrometer. This spectrometer provides useful spectral data for photon energies from 10 keV to 1 MeV. The array uses spheres of various materials and thicknesses around individually calibrated CaF_2:Mn "chip" TLDs. This spectrometer can provide a one-day turnaround of spectra for different simulator configurations providing calibration equipment is available.

Pinhole Photography

Pinhole photographs are occasionally used to identify and size radiation patterns produced by the machines. A dark room and development lab is available on site to process the pinhole camera photographs. There is an extra charge for the use of pinhole photography.

Photodetectors

Photoconductive photodetectors are currently being developed for use at the facility. Due to their small size, these devices should be able to measure the dose rate at various locations in and around the user's experiment that are currently unavailable for direct measurement. The photodetectors would be available in limited numbers and would not be intended to totally replace the standard method of measuring dose rate. As the work on these photodetectors is ongoing, their availability cannot be guaranteed.

General

The Casino/Phoenix/TAGS instrumentation is organized into the Simulator Data System (SDS) and the User Data System (UDS). Each system is a computer controlled system of high-speed transient digitizers which acquires, analyzes, displays and stores waveform data in digital form.

The current systems include Tektronix 7912AD and LeCroy 6880A, 8818A, and 8828D digitizers and DEC PDP-11 and VAX minicomputers and AST 386 and Zenith 286 microcomputers.

Simulator Data System (SDS)

The SDS monitors the performance of the facility simulators and provides information to support user testing. Its primary purpose is to track the operation of the machines and to help diagnose malfunctions when they occur. It also routinely records the scintillator-photodiode waveforms used in the dose rate calculation. Typical normalized photodiode traces for the Casino/Phoenix, TAGS, and the Febetron simulators are shown in Figures 14 through 16.

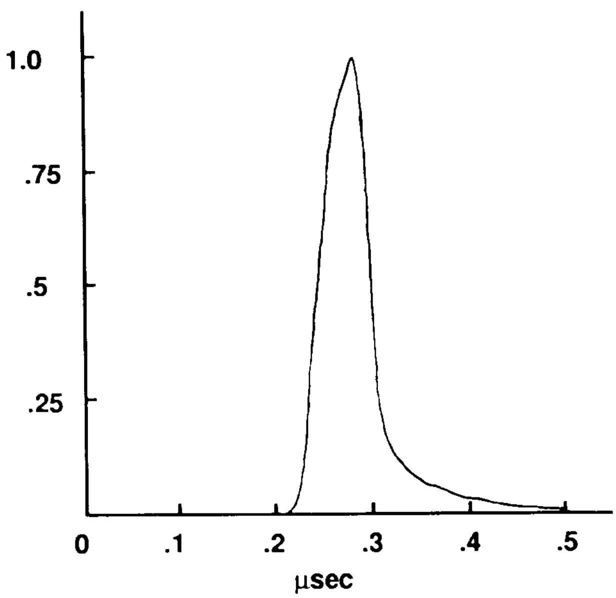


Figure 14a. Typical Casino Photodiode

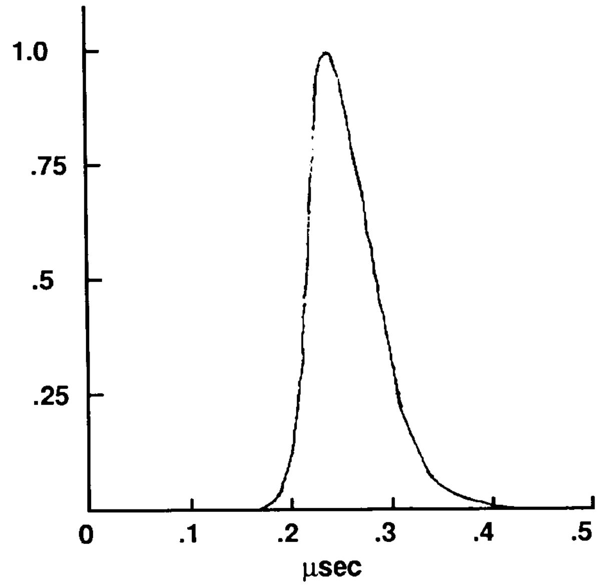


Figure 14b. Typical Phoenix Photodiode

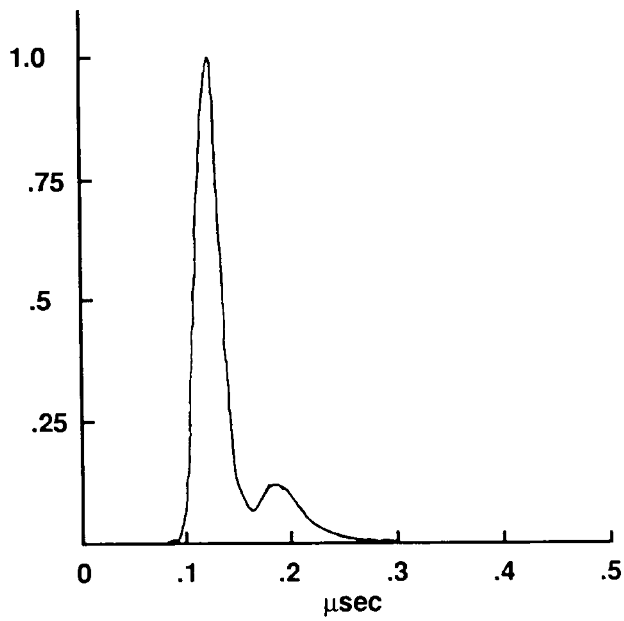


Figure 15. TAGS Photodiode

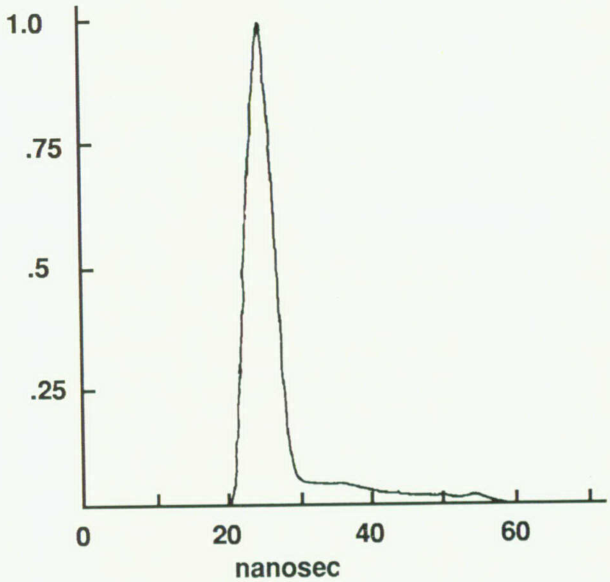


Figure 16a. Typical Febetron 706 Photodiode

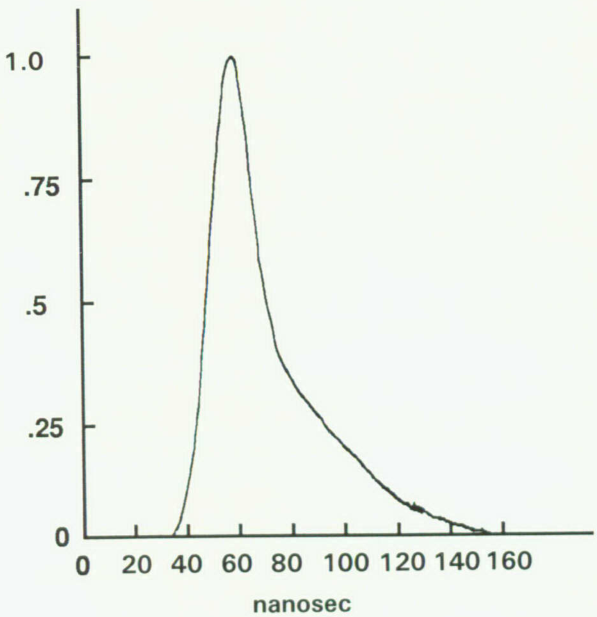


Figure 16b. Typical Febetron 705 Photodiode

The waveforms recorded are different for each machine but typically include: Marx voltage, pulse line voltage, diode voltage and current, photodiode voltage, and calculated diode characteristics such as power, energy, impedance. When of interest, the electron beam energy spectrum and power spectrum can be recorded. Any of this information is available to the interested user upon request.

User Data System (UDS)

The UDS is dedicated to the user and provides a variety of fast and slow channels for gathering radiation response information and performance data from the experiment. A simple data manipulation program allows you to process your data. Data are stored on hard disk and backed up on floppy disk for processing at a later time.

Photographs of the Casino/Phoenix/TAGS instrumentation system are shown in Figures 17 through 19, respectively. A list of the channels available in the UDS is shown in Table 6.

Figure 17. Facility Data Room

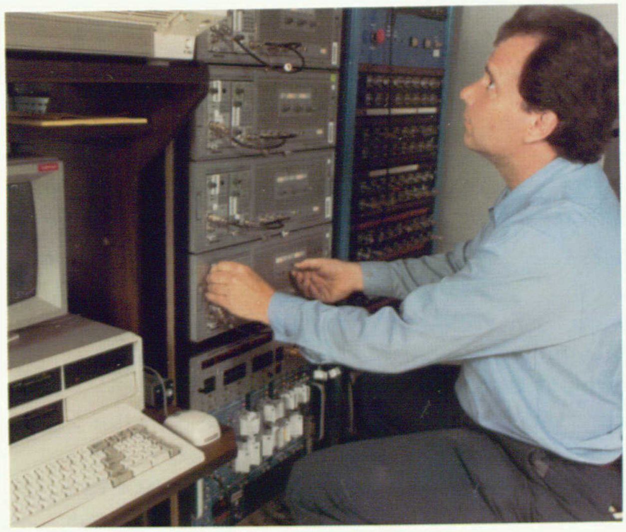


Figure 18. User Data Room

Figure 19. Control Room

Table 6. UDS Computerized Channels

No.	Item
4	Tektronix 7912ADs (100 kHz - 500 MHz)
2	LeCroy 6880A (400 MHz)
2	LeCroy LeCroy 8828D (200 Mhz)
4	LeCroy 8818A (100 MHz)
4	DSA602 Digitizing Signal Analyzer (1 GHz)
32	LeCroy 8212A (A to D slow)

More conventional types of instrumentation can also be made available to the user on request. Table 7 lists the instrumentation equipment reserved for customer use. The use of other instruments may also be arranged if the items are in stock. The UDS instrumentation is housed in a "class A" rf shield room. A network of double-shielded cables connect the instrumentation in this room to the experiments in the Phoenix and the Casino blockhouses. There are also conduits and trenches for routing user-supplied cables into the blockhouses from the rear of the user screen room and other locations (see Figure 20).

Table 7. Conventional Instrumentation

No.	Item
8	7000 Series oscilloscopes
8	C-51 cameras
	Assorted meters, power supplies, generators
1	Video camera and recorder
48	Single-ended double-shielded signal line cables
1	Open 6-inch conduit for user-supplied cables
1	Open 3-inch conduit for user-supplied cables

Optional

If you intend to make use of the Casino/Phoenix instrumentation system or any of the optional equipment, you should include the equipment you need and the details of your overall instrumentation scheme in the DTTP. Even if you intend to furnish all of your own equipment and cabling, the details of your instrumentation scheme, including equipment location, power requirements, etc., should be included in the DTTP. Requests for special cable runs, fixtures, or equipment must be arranged with the instrumentation coordinator and you will be charged time and material for these.

You may contact the Casino/Phoenix Instrumentation Coordinator (202) 394-2428 for additional information on the available instrumentation or for help with the preparation of the instrumentation portion of your plan. A message may also be left with the OA at (202) 394-1878.

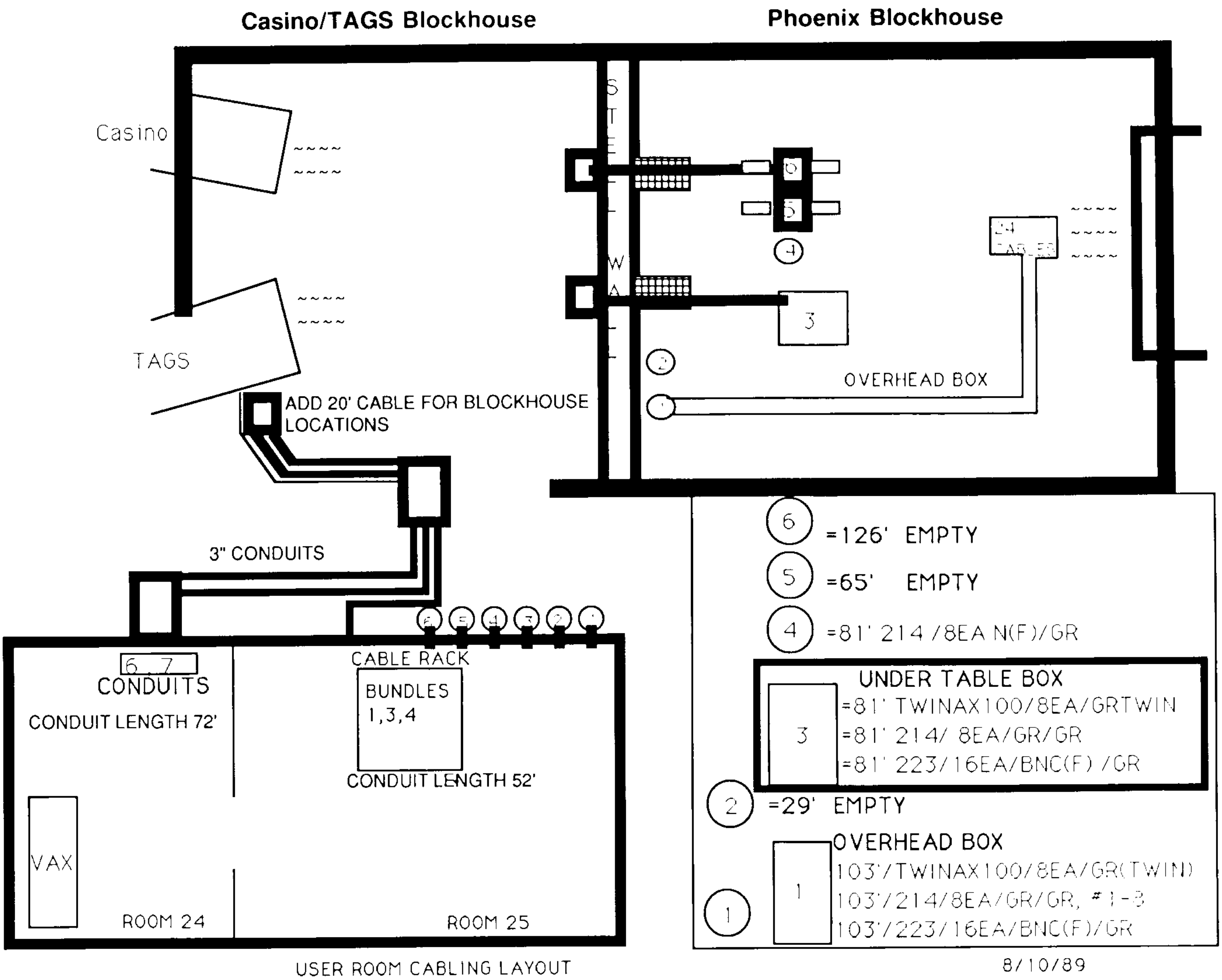


Figure 20. Conduit runs

Phoenix and Casino/TAGS Exposure Cells

The Phoenix radiation exposure cell measures 36 feet long by 19 feet wide and has a ceiling height of 20 feet. There is a 5 by 6 foot seismic block in the center of the room at floor level. The roof of the cell is removable should the need arise to move an object into it which is larger than the door. The cell is completely air-conditioned and ventilated through special filters. An adequate supply of power outlets is provided within the cell. The cell is an rf shield as well as a radiation shield. The Casino/TAGS exposure cell is immediately adjacent to the Phoenix cell and shares a common wall. This cell measures 20 feet long by 12 feet wide and has a ceiling height of 12 feet. The Phoenix and Casino/TAGS exposure cells are shown in Figure 21.

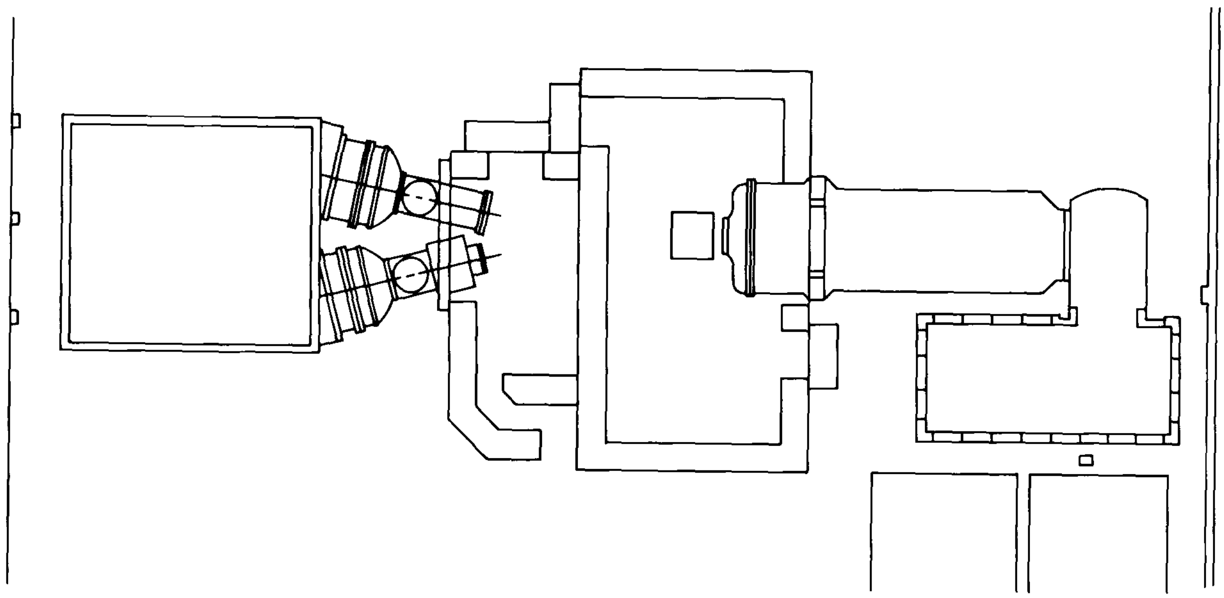


Figure 21. Phoenix and Casino/TAGS Exposure Cells

User Data Room Casino/Phoenix

The User Data Room is located adjacent to the Casino/TAGS exposure cell and may be occupied during operations. The room is an all steel rf enclosure and has a shielding effectiveness of at least 120 dB for electric fields from 1 kHz to 100 MHz and plane wave fields from 400 MHz to 10 GHz. The portion of the room available to users measures 25 by 15 feet. The User Data Room can be powered by a motor generator set to smooth incoming commercial power. Isolation transformers are used to inhibit the transfer of noise into the room via the power lines.

Trailer Area

The Casino Building can accommodate two large (50 × 100 feet) instrumentation trailers inside the high bay adjacent to the exposure cells. Provisions for power, air conditioning exhaust, and instrumentation conduits are available in the trailer area.

Secure Vault

The Casino Building has a large vault for storage of classified hardware. The vault measures 12 feet by 14 feet and has a 3-foot door.

User Office

An office is available for users. This room measures 10 feet by 14 feet. It contains an IBM-compatible computer with modem, a conference table for data analysis, dustless chalkboards, basic tools, and coat racks.

Machine Shop

A wide range of design and fabrication techniques are available in the facility machine shop (see Figure 22). Qualified machinists are available to fabricate hardware to meet user's needs.

Figure 22. Machine Shop

Febetrons and Co60 Exposure Rooms

The Febetrons (705, 705X, and 706) and the Co60 source are housed on the lower level of the Navy's Vulnerability and Hardening Building in a series of x-ray exposure rooms. A plan view of these rooms is shown in Figure 23. A detailed dimensioned sketch of the Febetron room is shown in Figure 24. All three of the Febetrons are located in this room. The other rooms are similar.

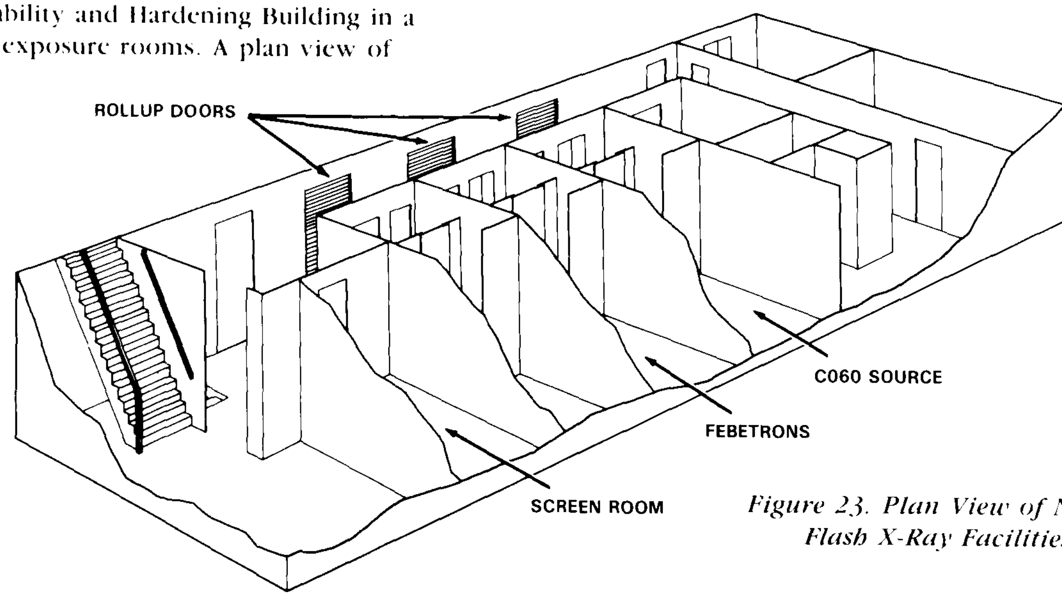


Figure 23. Plan View of NSWC Flash X-Ray Facilities

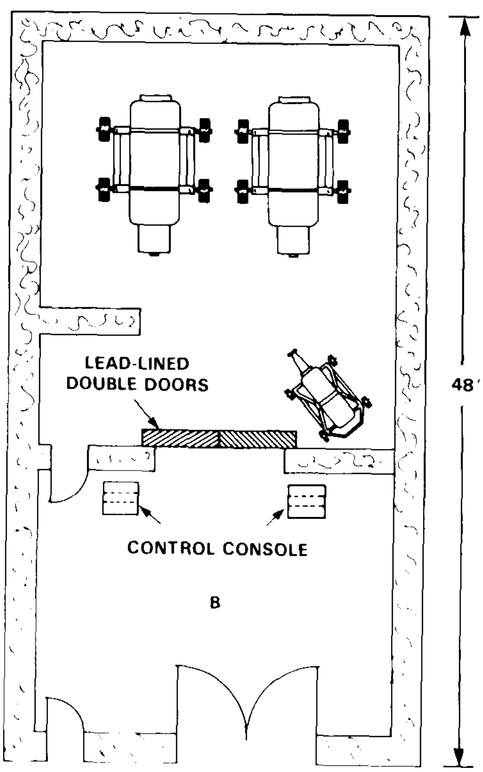


Figure 24. Febetron Room Layout

Data and control cables for Febeton experiments are typically routed via cable ladders from the exposure rooms to the control rooms. Users may occupy the control rooms when the machines are fired. Users may also locate their instrumentation in the rf shield room if a quieter environment is necessary. Instrumentation can also be located immediately adjacent to the Co60 source.

Handling Equipment

A 20-ton crane spans the entire trailer and simulator area of the Casino Building's high bay. There is a 4-ton crane in the Phoenix exposure cell. There are also three fork lifts and an assortment of handcarts and portable lifting equipment available.

Security

All of the Facilities described in this brochure are located within the NSWC interior security area.

1. Visit Requests (security clearances) must be on file at NSWC prior to the first visit to the Casino/Phoenix/TAGS facility.

2. Visit requests should be forwarded to:

Naval Surface Warfare Center
White Oak Laboratory
Attn: Receptionist/Visitor Control, Code X11
10901 New Hampshire Avenue
Silver Spring, MD 20903-5000

3. Late visit requests may be telecopied to NSWC at (202) 394-1373/verification is (202) 394-1236.

4. All persons visiting the Casino/Phoenix/TAGS Facility must sign in with the NSWC receptionist in the Administration Building and be issued a badge. Unescorted badges will only be issued to government employees who have security clearances on file and DoD contractors who have security clearances and a memo from the Operations Assistant requesting that they be unescorted.

5. Badges must be worn and must be visible at all times while visiting NSWC.

6. Badges must be returned to the NSWC receptionist or guard upon leaving the secured area, whether for lunch or for the day. New badges will be issued by the receptionist upon return.

7. Cameras and tape recorders are not permitted in the facility unless permission has been granted by the NSWC Security Officer prior to the visit.

8. Visitors with unescorted privileges are restricted to travel to and from Building 132 and the main gate or the cafeteria/arcade area. Visitors should not tour other areas of the base unescorted.

Flash x-ray machines pose two potential hazards to personnel when they are being operated: electric shock and radiation exposure.

Since the x-radiation generated by all of the machines (except for the Co60 source) is transient in nature and only occurs when the machine actually fires, there is no radiation hazard at any other time. In addition, the radiation is confined to the interior of the two blockhouses for Casino/TAGS and Phoenix, and the exposure rooms for the Febetrons. All of these exposure areas are equipped with safety interlocks which prevent a machine from firing if the area is not properly secured.

1. All persons visiting the Casino/Phoenix/TAGS facility must sign in and out at the main entrance of Building 132.

2. All persons must obtain a personal Access Control System (ACS) card from the Operations Assistant. The ACS card contains a personalized code which will identify the person by name to the access control monitors at certain control points. These cards are necessary in order to make sure everyone in the building is at a safe location during test shots. The ACS card must be worn at all times while in the building.

3. All persons must obtain a radiation film badge from the Operations Assistant and must wear it at all times.

4. All users of the Facility must read and be familiar with the Standard Operating Procedure (SOP) for user safety. A copy of this SOP will be given to all users by the operations assistant.

5. When the Casino/Phoenix/Tags machines are ready for firing, an announcement will be made over the PA system for all personnel to clear the high and low bay areas. Please leave the specified areas immediately and do not return until further notice is given.

6. When the announcement, "SHOT COMPLETE, AREAS ARE OPENED TO ALL PERSONNEL," is made, you may resume work in the high and low bay areas.

Travel and Accommodations

NSWC is convenient to Washington National Airport, Dulles International Airport, and Baltimore-Washington International Airport.

- From National Airport, drive north on the George Washington Parkway to the Capital Beltway, I-495, and turn North toward Maryland. Exit I-495 at MD-650 (New Hampshire Avenue North, White Oak). The Center is approximately 2 miles from the exit. Turn right into the main gate and park in the visitor's lot on the right. Walk to the main building and turn right inside of the door to the reception room.
- From Dulles, take the access road to I-495 and turn north to Maryland. Follow the directions above to NSWC.
- From Baltimore-Washington International Airport, take the Baltimore-Washington Expressway, 295, south to Washington Exit onto I-495 West, Silver Spring, and take the next exit off I-495 to MD-650 North, White Oak. Proceed as above. You may also continue on the Baltimore-Washington Expressway to I-95 North to I-495 West, Silver Spring, and avoid MD-175 if you wish.

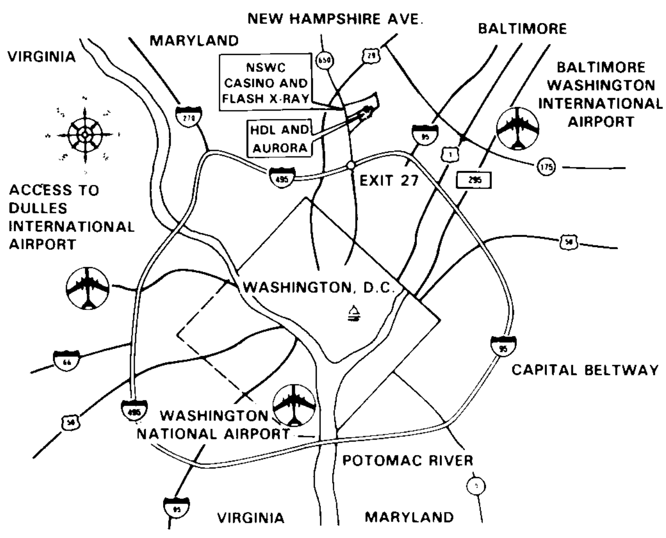


Figure 25. Major Highways and Routes From Airports to NSWC

- A small map of the major highways and airports and their locations relative to NSWC is shown in Figure 25.
- A map of the NSWC White Oak Laboratory is given in Figure 26.

There are numerous motel and hotel accommodations near the Center for your overnight stay. We have listed a few for your consideration. Please note that this list is not an endorsement of these particular establishments.

A partial list of lodging convenient to the White Oak Area follows:

Silver Spring — Capital Beltway (I-495)
Exits 30 or 31

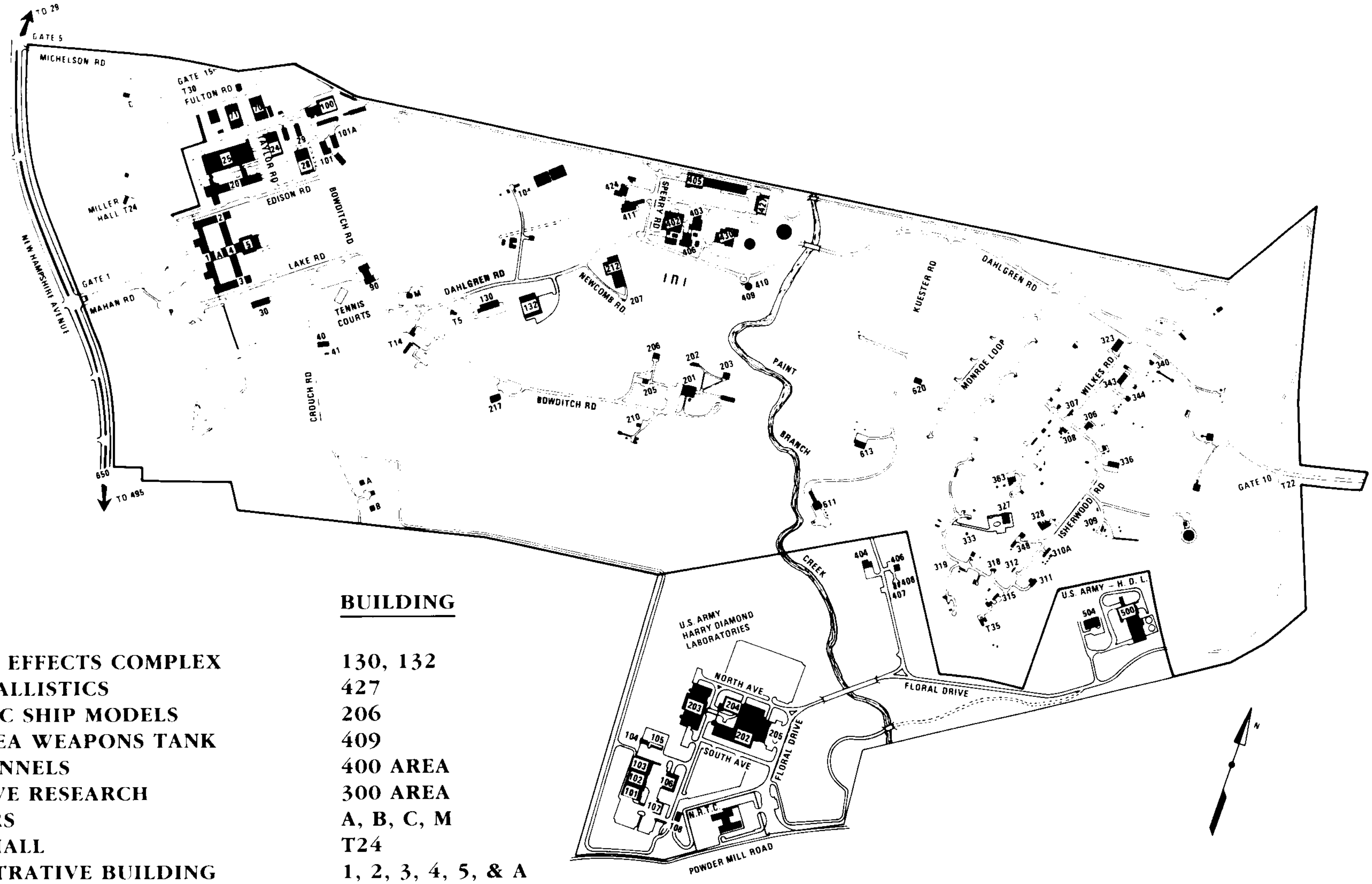
Holiday Inn 8777 Georgia Avenue Silver Spring, MD 20910	(301) 589-0800
Sheraton 8727 Colesville Road Silver Spring, MD 20910	(301) 589-5200

Beltsville — Capital Beltway (I-495/I-95)
Exit 27 toward I-95 Baltimore, Exit 29B

Ramada Inn 5050 Powder Mill Road Beltsville, MD 20705	(301) 572-7100

Route 1 — Capital Beltway (I-495/I-95)
Exit 25

Comfort Inn 9020 Baltimore Blvd. College Park, MD 20740	(301) 441-1810
Holiday Inn 9137 Baltimore Blvd. College Park, MD 20740	(301) 935-5000
Holiday Inn 1000 Baltimore Blvd. College Park, MD 20740	(301) 345-6700



FACILITY	BUILDING
NUCLEAR EFFECTS COMPLEX	130, 132
HYDROBALLISTICS	427
MAGNETIC SHIP MODELS	206
UNDER SEA WEAPONS TANK	409
WIND TUNNELS	400 AREA
EXPLOSIVE RESEARCH	300 AREA
QUARTERS	A, B, C, M
MILLER HALL	T24
ADMINISTRATIVE BUILDING	1, 2, 3, 4, 5, & A
FIRE DEPT	100
NAVY TACTICAL SUPPORT ACTIVITY	90
GATE 1 (FRONT)	19
GATE 10 (BACK)	T22
VISITOR PARKING	P

NSWC WHITE OAK LABORATORY
Silver Spring, Maryland

Figure 26

Defense Nuclear Agency